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OCTOBER, 1955. **Vol. L, No. 10**

FIFTIETH YEAR OF PUBLICATION

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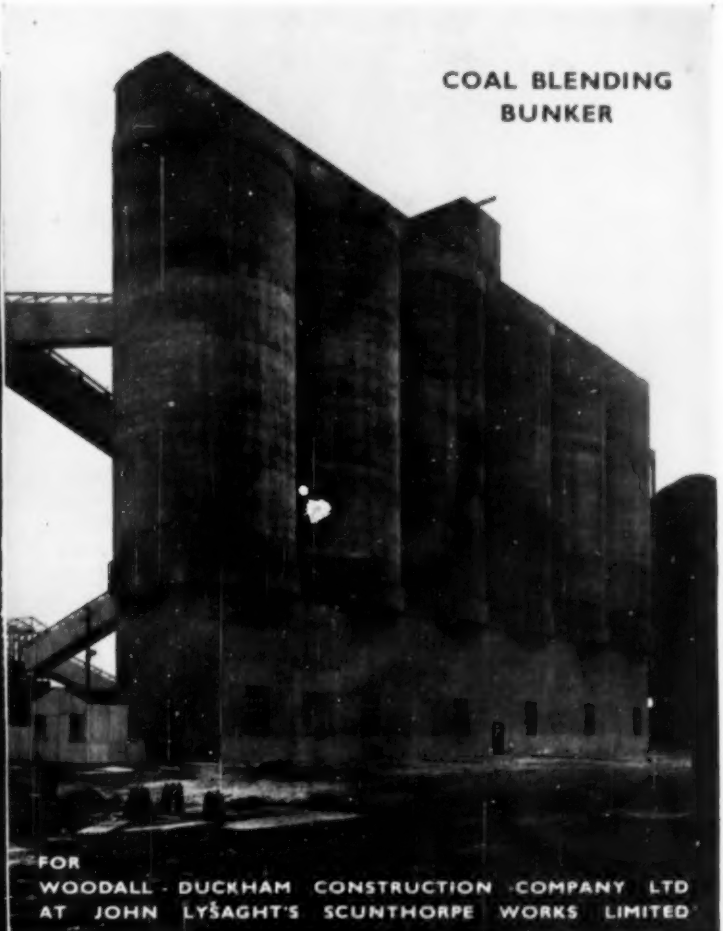
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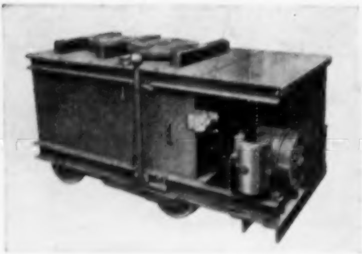

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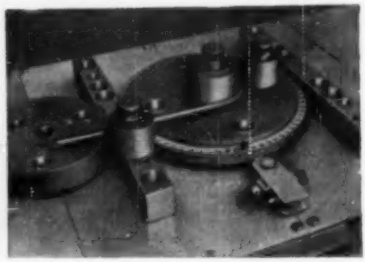

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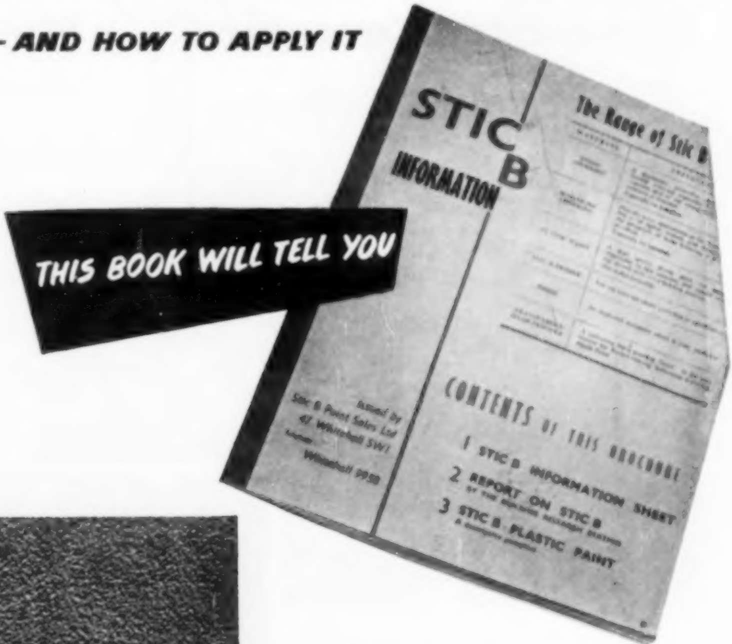

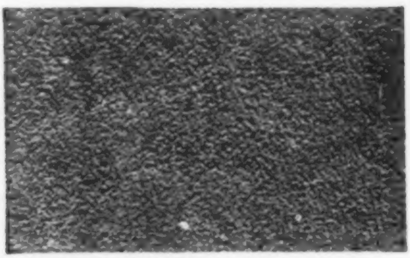
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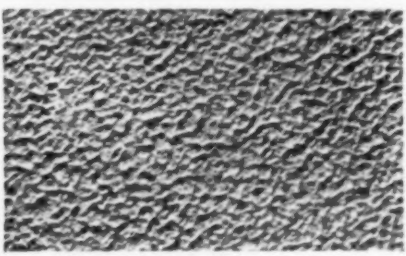
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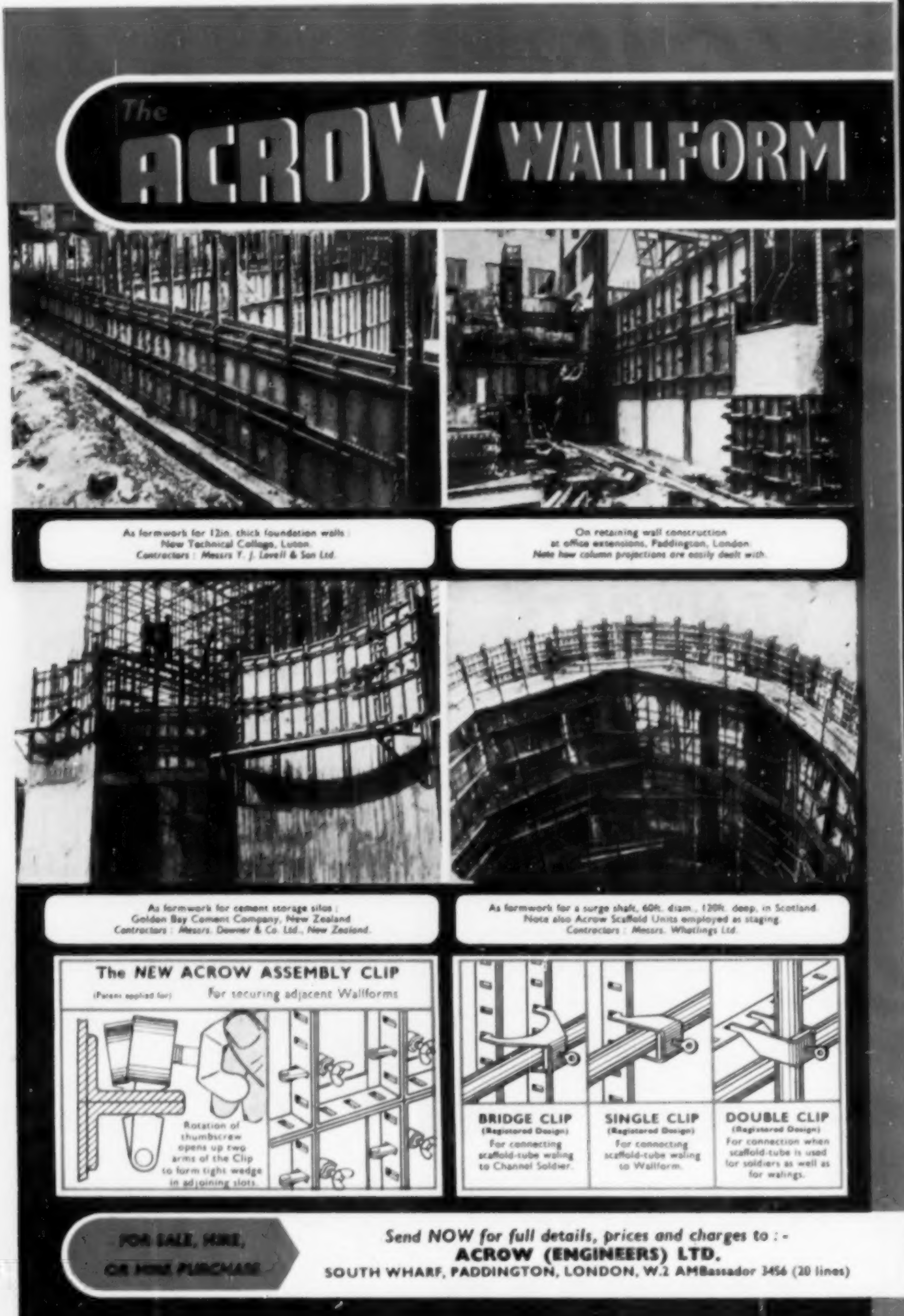
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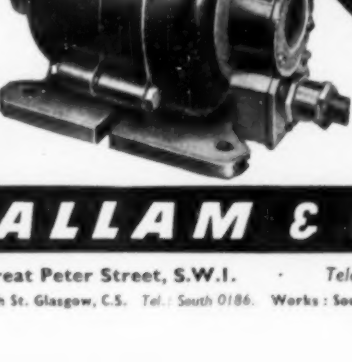

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CONCRETE
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Volume L, No. 10. LONDON, OCTOBER, 1955.

EDITORIAL NOTES

Concrete as a Protection against Nuclear Radiation.

THE use of concrete to provide protection against nuclear radiation will become increasingly important. An engineer responsible for providing such protection will no doubt in most cases have to be guided by physicists, but it is desirable that he should understand the principles he will have to apply. As little information is available on this subject, two relevant papers * may be brought to the notice of those who may be concerned in such work, and in the following the views of the authors are briefly presented.

The radiations against which protection is usually required are electromagnetic waves and nuclear particles. Electromagnetic waves are generally X-rays and gamma-rays, which are similar to light rays but of higher energy and greater penetrating power. These waves are not continuous but are emitted in small quantities called photons which have many of the properties, such as mass, momentum, and energy, of a small particle. The nuclear particles may be neutrons, protons, α-particles (which comprise two neutrons and two protons), and β-particles (which are electrons emitted from certain nuclei). Except for the neutrons, all these particles are electrically charged and consequently are affected by the electrical fields surrounding atoms.

The attenuation of the electromagnetic waves is brought about in several ways, of which the most important are photoelectric absorption, scattering, and the production of pairs of electrons in the absorbing material. In photoelectric absorption the photon ejects an electron from an atom of the absorbing material and in so doing the photon disappears, excess energy appearing as kinetic energy of the ejected electron. The effectiveness of a barrier is thus related to the difference between the energy of a photon and that required to eject an electron from an atom of the material composing the barrier ; in concrete the effect is small. Scattering is the result of collisions between photons and electrons in the atomic structure of the barrier, and the laws of mechanics relating to the conservation of momentum and energy are applicable. Thus a photon loses part of its energy to an electron ; in addition, its direction of travel is changed so that, in general, it must travel a longer path to pass through the barrier and thus has a lower penetrating power. The attenuating power of a barrier will therefore be approximately proportional to the number of electrons in the path

* "Absorption by Concrete of X-rays and Gamma-rays," by B. E. Foster ; "Concrete for Radiation Shielding," by E. J. Callan. Journal of the American Concrete Institute, September, 1953.

of a photon, and in this respect concrete is a more effective material than lead, particularly when dense aggregates such as iron or iron ores are used. The third way in which the energy of penetration of a photon is reduced is by the production, in certain conditions, of a pair of electrons, one positively charged and one negatively charged, close to the nucleus of an atom. The photon disappears in the process and the excess energy is transferred to the electrons as kinetic energy. Concrete is far less resistant to this action than is lead.

Neutrons are the most important of the particles, as their penetrating power is much greater than that of particles with an electrical charge. The energy of neutrons may be reduced by collisions with nuclei and the capture by nuclei of neutrons of reduced energy. In the latter case gamma-rays may be emitted by nuclei. The collisions are followed by scattering of the paths of the neutrons. The nuclei of hydrogen atoms have about the same mass as neutrons and so are most effective in reducing the speed of the neutrons ; atoms of oxygen are the next most effective. The presence of these elements in a neutron shield is most desirable, and in concrete this is best accomplished by a high water content.

The calculation of the thickness of a barrier required to reduce the passage of radiation to that considered safe is based upon units known as " half thicknesses," so that, if a wall is divided into layers of equal thickness such that each layer will absorb half the radiation striking it, then (assuming unit intensity to start with) the intensity on the far side of the first layer will be one-half, after passing through two layers the intensity will be one-quarter, and after three layers it will be one-eighth. The coefficients of absorption for various materials have been obtained experimentally so that the required number of " half-thicknesses " can be calculated in a simple manner. In using these coefficients care must, however, be taken to ensure that the conditions under which they were obtained are comparable with those to which they are to be applied. Principally it is necessary to distinguish between so-called " broad-beam " and " narrow-beam " conditions. The principal attenuating effect of concrete lies in its scattering effect. If a narrow beam of radiation is directed at a barrier the measuring device on the opposite side of the barrier will record those rays passing directly through the barrier but not the rays deviated from their paths by chance collisions and so passing out of the barrier beyond the measuring device. If, however, a broad beam of rays is directed at the barrier then scattered rays from parts of the beam not directly in line with the measuring device may also be measured by it although they have been deviated from their direct path by collisions. [A method of calculation was described in this journal for April, 1952.]

When nuclear radiation was confined to low energies of emission, lead was the most common protective barrier. As the energy of emission increased so the thickness of the barrier had to be increased, and difficulties were experienced with lead due to its lack of mechanical strength. Thus it became necessary to find a material which, while having the necessary protective properties, was also able to support itself and special concretes have been developed for this purpose. The effectiveness of concrete is roughly proportional to its unit weight and, because of the thicknesses of the barrier required for high-energy emission, it is frequently cheaper to use special dense aggregates even though these may cost many times as much as more common aggregates.

The Analysis of Frames by the Nomographic Method.—1.

A Labour-saving Aid in Design.

By J. RYGOL, B.Sc.(Eng.).

A NOMOGRAPHIC method of analysing a frame with both columns hinged at the base is presented, and nomograms are given for eight different conditions of simple loading; any other loading may be obtained by superposition. The eight cases are referred to as Standard Loadings, and are:

(A) Vertical loading on beam CD.—(1) Single concentrated load W at a distance αl from C. (2) Uniformly-distributed load W extending a distance αl from C. (3) Triangular load W extending a distance αl from C.

(B) Horizontal loading on column AC.—(4) Single concentrated load W at a distance βh from A. (5) Uniformly-distributed load W extending a distance βh from A. (6) Triangular load W extending a distance βh from A.

(C) External Moment.—(7) M on beam CD at a distance αl from C. (8) M on column AC at a distance βh from A.

Symmetrical and antimetrical Standard Loadings receive special attention.

The geometrical properties of the frame (span l, height h, moments of inertia I_1 and I_2) are characterised by the non-dimensional factor z, which equals $\frac{I_1 h}{I_2 l}$; z, being a function of the shape of the frame, is termed the "shape factor".

The position of the load is defined by a non-dimensional co-ordinate α (load on beam CD) or β (load on column AC).

Sign Convention.

LOADING.—(1) Loads are positive when acting towards the inside of the frame (*Fig.* 1). (2) External moments are positive when acting clockwise on beam CD and column AC and anti-clockwise on column BD (*Fig.* 2).

BENDING MOMENTS AND FORCES.—(1) Forces H_A, H_B, V_A, and V_B are positive when acting in the directions of the arrows in *Fig.* 3. (2) Moments are positive when producing tension at the inner side of the member. In the bending-moment diagrams the moments are plotted on the tensile side of the members.

A frame with both columns hinged at the base is once statically indeterminate (*Fig.* 4*a*). The horizontal thrust H_B at B is assumed to be the redundant quantity

Fig. 1.

Fig. 2.

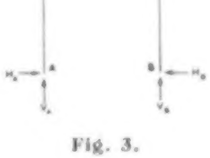


Fig. 3.

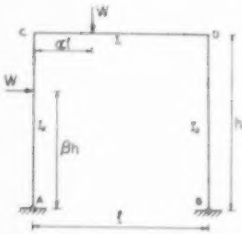


Fig. 4 (a).

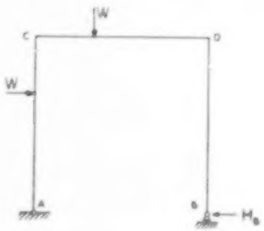


Fig. 4 (b).

(*Fig.* 4*b*). The thrust H_B can be expressed as a product of the total load on the frame $\left(\text{or } \dfrac{M}{h} \text{ in the case of the external moment}\right)$ and a non-dimensional coefficient c. $H_B = cW$ for Standard Loadings 1 to 6; $H_B = c\dfrac{M}{h}$ for Standard Loadings 7 and 8.

In the case of the vertical load on beam CD (Standard Loadings 1, 2, and 3) the coefficient $c = kc_0$, where c_0 is the coefficient of horizontal thrust when a concentrated load is applied at the centre of the span (c_0 is a function of the shape factor and the ratio $\left.\dfrac{l}{h}\right)$ and k is a non-dimensional coefficient depending only on the position of the load as determined by the non-dimensional co-ordinate α. The coefficient c_0 is obtained from Nomogram No. 1, and values of k_1, k_2, and k_3 are read from *Graph* No. 1.

For all other cases of loading (Standard Loadings 4 to 8), c is a function of the shape factor and the position of the load; the latter is denoted by the non-dimensional co-ordinate α (the load on beam CD) or β (the load on column AC). Coefficients c_4 to c_8 for Standard Loadings 4 to 8 are obtained from Nomograms Nos. 4 to 8 respectively.

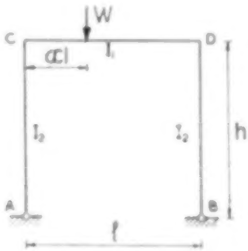
Other cases of loading can be analysed by superposition of the eight Standard Loadings.

[The Nomograms are numbered to correspond with the numbers of the Standard Loadings. Nomograms Nos. 5 to 8 will be given in the concluding part of this article.]

Formulæ for c.

$$z = \frac{I_1 h}{I_2 l}. \qquad r = \frac{l}{h}.$$

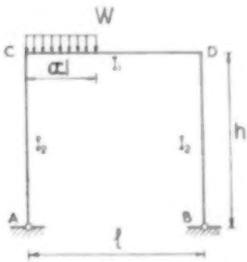
For loadings 1, 2, and 3, $c_0 = \dfrac{3r}{8(3 + 2z)}$. Coefficients k_1, k_2, and k_3 are obtained from *Graph* No. 1 and c_0 from Nomogram No. 1.



LOADING 1.—

$c_1 = c_0 k_1$.

$k_1 = 4\alpha(1 - \alpha)$.

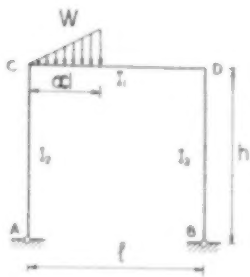


LOADING 2.—

Total load $W = w\alpha l$.

$c_2 = c_0 k_2$.

$k_2 = \frac{2}{3}\alpha(3 - 2\alpha)$.

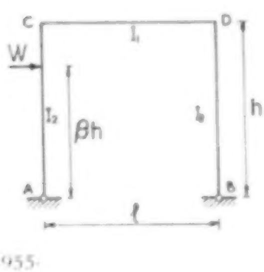


LOADING 3.—

Total load $W = w\dfrac{\alpha}{2}l$.

$c_3 = c_0 k_3$.

$k_3 = \frac{2}{3}\alpha(4 - 3\alpha)$.



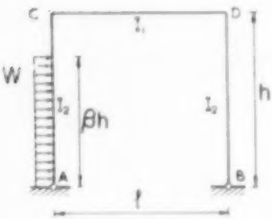
LOADING 4.—

$$c_4 = \frac{z(3 - \beta^2)\beta + 3\beta}{2(3 + 2z)}.$$

(Nomogram No. 4.)

Formulæ for the coefficient *c*.

(continued.)

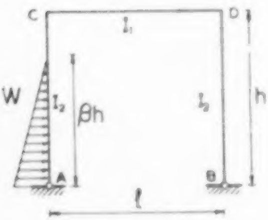


LOADING 5.—

Total load $W = w\beta h$

$$c_5 = \frac{z(6 - \beta^2)\beta + 6\beta}{8(3 + 2z)}.$$

(Nomogram No. 5.)

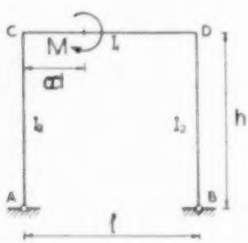


LOADING 6.—

Total load $W = w\frac{\beta}{2}h$

$$c_6 = \frac{z(10 - \beta^2)\beta + 10\beta}{20(3 + 2z)}.$$

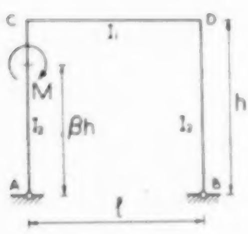
(Nomogram No. 6.)



LOADING 7.—

$$c_7 = \frac{3(1 - 2\alpha)}{2(3 + 2z)}$$

(Nomogram No. 7.)



LOADING 8.—

$$c_8 = \frac{3z(1 - \beta^2) + 3}{2(3 + 2z)}$$

(Nomogram No. 8.)

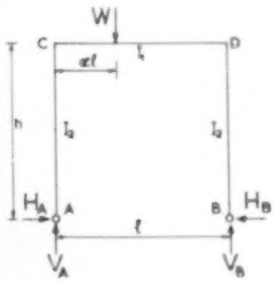
Formulæ for Bending Moments and Forces.

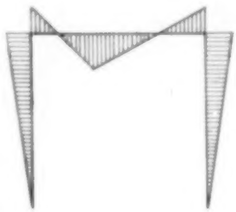
$$z = \frac{I_1 h}{I_2 l}, \qquad r = \frac{l}{h}.$$

VERTICAL LOADING ON BEAM CD.

Standard Loading 1.—Concentrated load. c_0 from Nomogram No. 1. k_1 from *Graph* No. 1. $c_1 = k_1 c_0$.

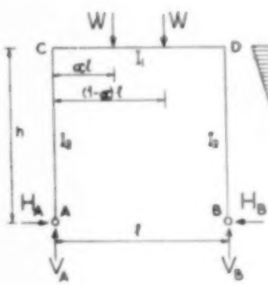
Simple Loading.—

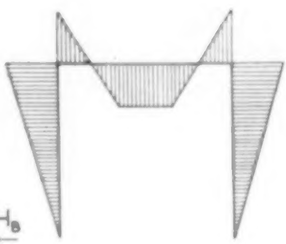




$$H_A = H_B = c_1 W.$$
$$M_C = M_D = -c_1 Wh.$$
$$M_\alpha = [\alpha(1-\alpha)r - c_1]Wh.$$
$$V_B = \alpha W.$$
$$V_A = W - V_B = (1-\alpha)W.$$

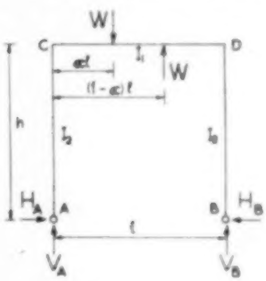
Symmetrical Loading.—

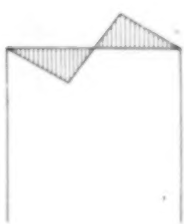




$$H_A = H_B = 2c_1 W.$$
$$M_C = M_D = -2c_1 Wh.$$
$$M_\alpha = M_{1-\alpha} = (\alpha r - 2c_1)Wh.$$
$$V_A = V_B = W.$$

Antimetrical Loading.—



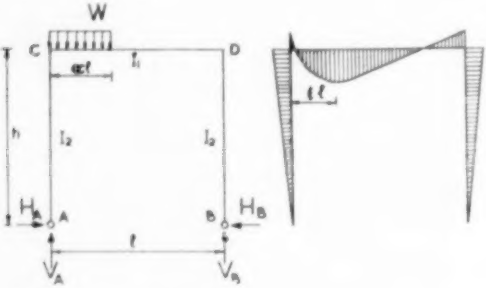


$$H_A = H_B = 0.$$
$$M_C = M_D = 0.$$
$$M_\alpha = -M_{1-\alpha} = \alpha(1-2\alpha)Wl.$$
$$V_A = -V_B = (1-2\alpha)W.$$

Vertical Loading on Beam CD.

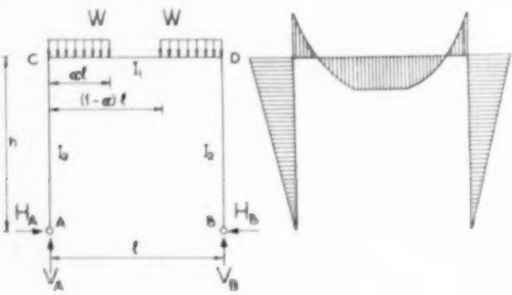
Standard Loading 2.—Uniformly-distributed load. Total load $W = w\alpha l$. c_0 from Nomogram No. 1. k_2 from *Graph* No. 1. $c_2 = k_2 c_0$.

Simple Loading.—



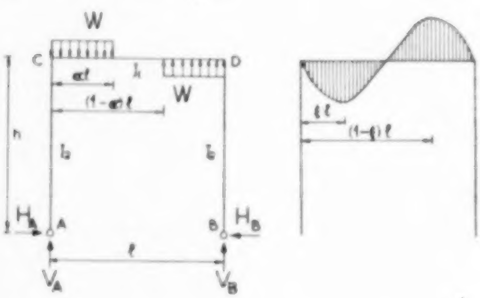
$$H_A = H_B = c_2 W.$$
$$M_C = M_D = -c_2 W h.$$
$$M_\xi = \left[\frac{\alpha(2-\alpha)^2}{8} r - c_2\right] Wh;$$
$$\xi = \frac{\alpha(2-\alpha)}{2} = \alpha \frac{V_A}{W}.$$
$$V_B = \frac{\alpha}{2} W.$$
$$V_A = W - V_B = \left(1 - \frac{\alpha}{2}\right) W.$$

Symmetrical Loading.—



$$H_A = H_B = 2c_2 W.$$
$$M_C = M_D = -2c_2 W h.$$
$$M_\alpha = M_{1-\alpha} = \left(\frac{\alpha}{2} r - 2c_2\right) Wh.$$
$$V_A = V_B = W.$$

Antimetrical Loading.—

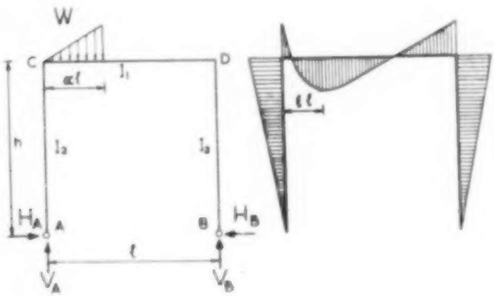


$$H_A = H_B = 0.$$
$$M_C = M_D = 0.$$
$$M_\xi = -M_{1-\xi} = \frac{\alpha(1-\alpha)^2}{2} Wl;$$
$$\xi = \alpha(1-\alpha) = \alpha \frac{V_A}{W}.$$
$$V_A = -V_B = (1-\alpha) W.$$

Vertical Loading on Beam CD.

Standard Loading 3.—Triangular load. Total load $W = w\frac{\alpha}{2}l$. c_0 from Nomogram No. 1. k_3 from *Graph* No. 1. $c_3 = k_3c_0$.

Simple Loading.—



$H_A = H_B = c_3W.$

$M_C = M_D = - c_3Wh.$

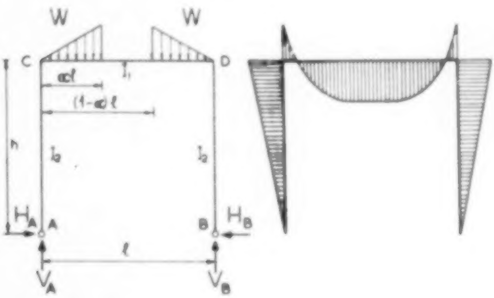
$M_\xi = [\frac{2}{3}\alpha r\sqrt{(1 - \frac{2}{3}\alpha)^3} - c_3]Wh;$

$\xi = \alpha\sqrt{1 - \frac{2}{3}\alpha} = \alpha\sqrt{\frac{V_A}{W}}.$

$V_B = \frac{2}{3}\alpha W.$

$V_A = W - V_B = (1 - \frac{2}{3}\alpha)W.$

Symmetrical Loading.—



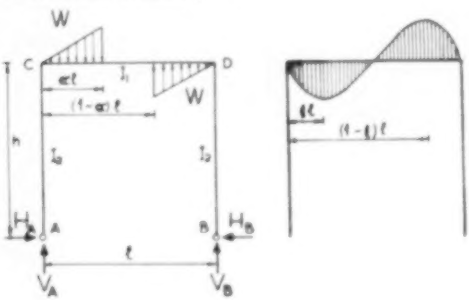
$H_A = H_B = 2c_3Wh.$

$M_C = M_D = - 2c_3Wh.$

$M_\alpha = M_{1-\alpha} = (\frac{2}{3}\alpha r - 2c_3)Wh.$

$V_A = V_B = W.$

Antimetrical Loading.—



$H_A = H_B = 0.$

$M_C = M_D = 0.$

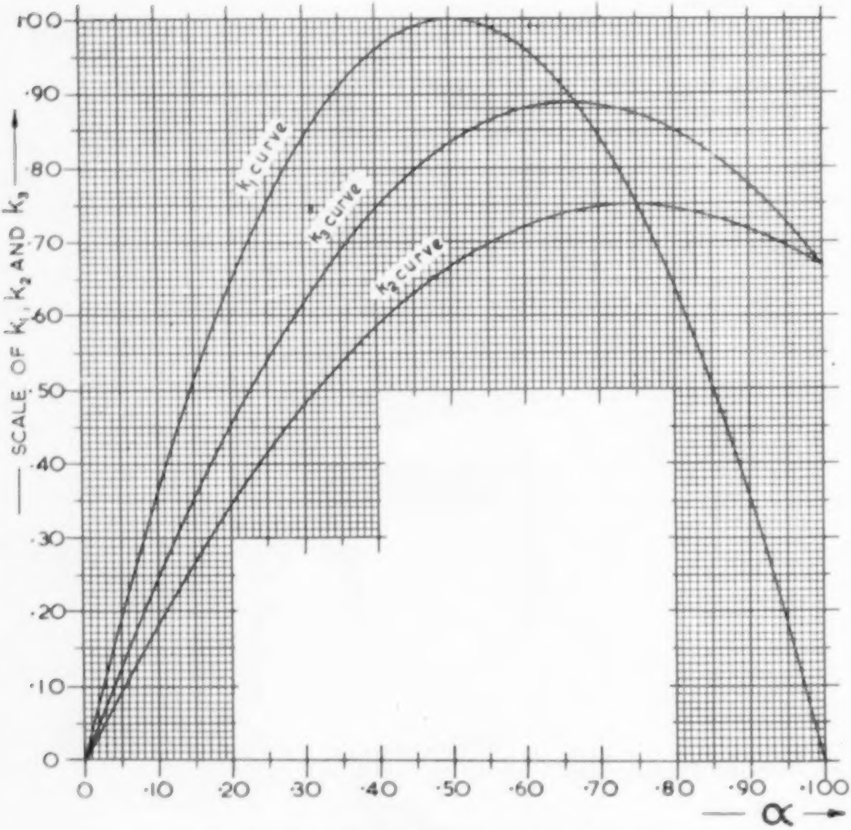
$M_\xi = - M_{1-\xi}$

$= [\frac{2}{3}\alpha\sqrt{(1 - \frac{4}{3}\alpha)^3}]\ Wl;$

$\xi = \alpha\sqrt{(1 - \frac{4}{3}\alpha)} = \alpha\sqrt{\frac{V_A}{W}}.$

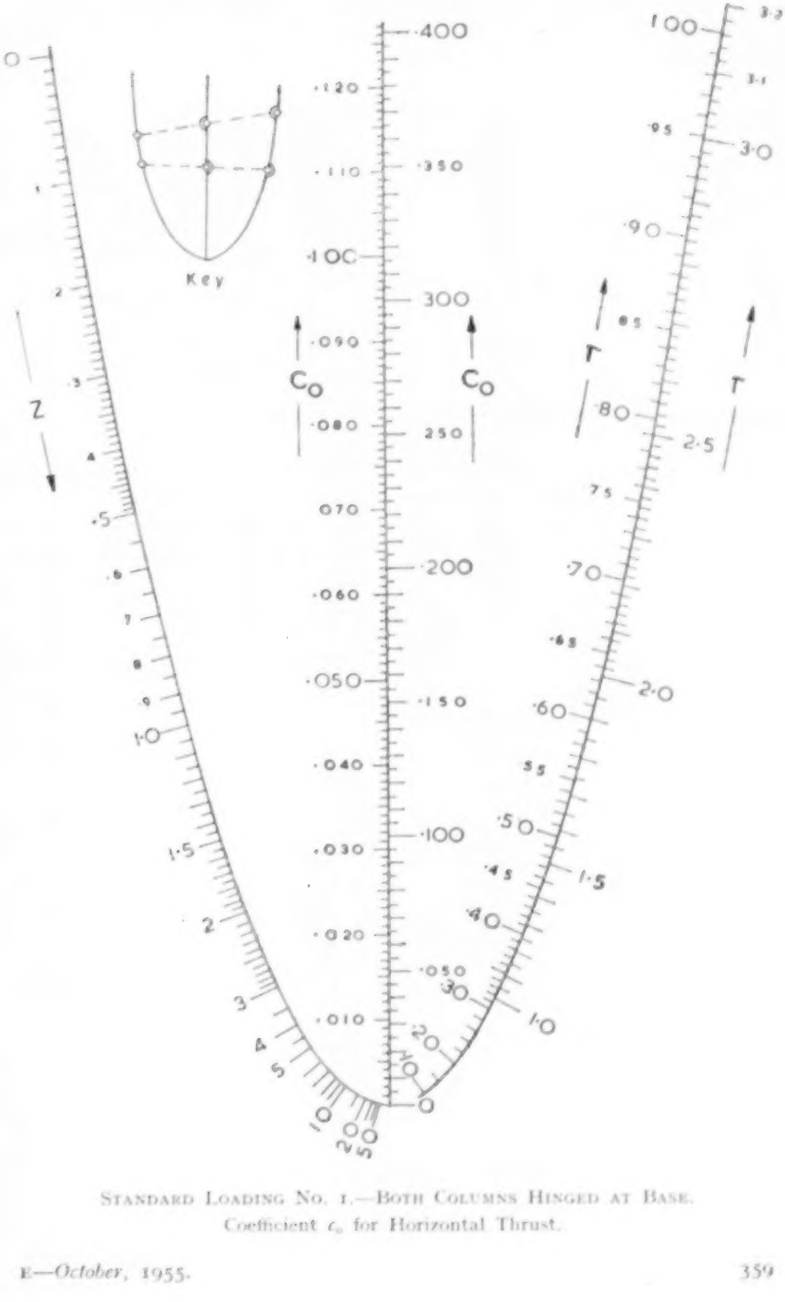
$V_A = - V_B = (1 - \frac{4}{3}\alpha)W.$

GRAPH NO. 1.—STANDARD LOADINGS NOS. 1, 2 and 3.



Frame with Both Columns Hinged at the Base.
Coefficients k_1, k_2, and k_3 for Horizontal Thrust.

Nomogram No. 1.

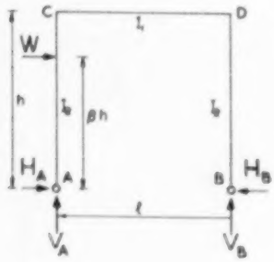


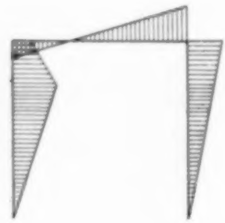
Standard Loading No. 1.—Both Columns Hinged at Base.
Coefficient c_0 for Horizontal Thrust.

Horizontal Loading on Column AC.

Standard Loading 4.—Concentrated load. c_4 from Nomogram No. 4.

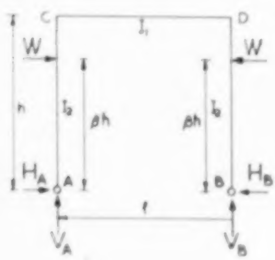
Simple Loading.—

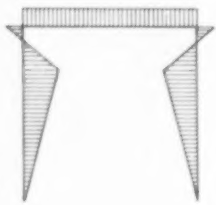




$H_B = c_4 W.$
$H_A = -(1 - c_4)W.$
$M_C = (\beta - c_4)Wh.$
$M_D = -c_4 Wh.$
$M_\beta = (1 - c_4)\beta Wh.$
$V_B = -V_A = \frac{\beta}{r}W.$

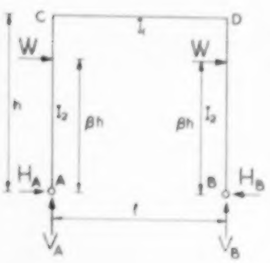
Symmetrical Loading.—

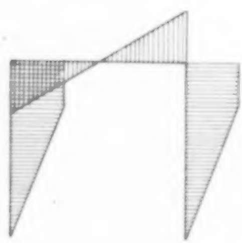




$H_A = H_B = -(1 - 2c_4)W.$
$M_C = M_D = (\beta - 2c_4)Wh.$
$M_\beta = (1 - 2c_4)\beta Wh.$
$V_A = V_B = 0.$

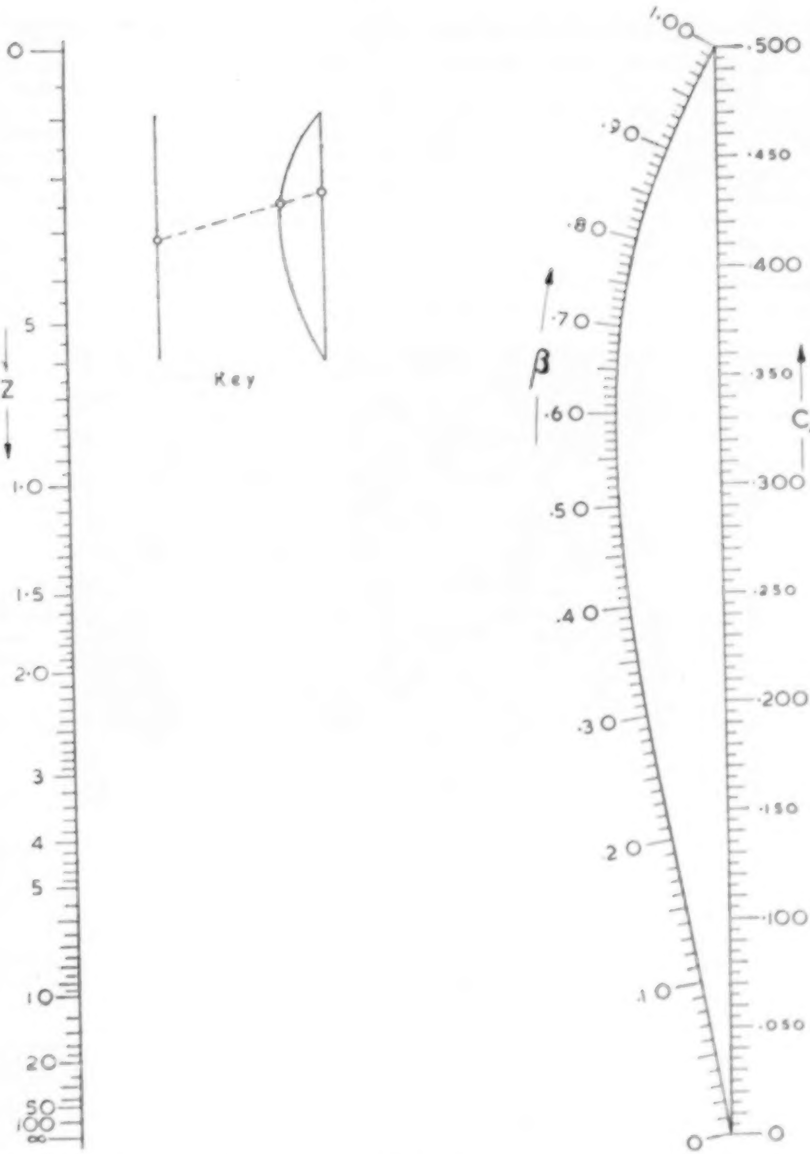
Antimetrical Loading.—





$H_A = -H_B = -W.$
$M_C = -M_D = \beta Wh.$
$M_{\beta(AC)} = -M_{\beta(BD)} = \beta Wh.$
$V_A = -V_B = -2\frac{\beta}{r}W.$

Nomogram No. 4.



STANDARD LOADING NO. 4.—BOTH COLUMNS HINGED AT BASE.
Coefficient c_4 for Horizontal Thrust.

(*To be concluded.*)

Book Reviews.

"**Foundation Engineering.**" By R. Hammond. (London: Odhams Press, Ltd. 1955. Price 21s.)

THIS is not a text-book on soil mechanics in the generally-accepted sense, for after the first two chapters describing types of soils, methods of testing, and site investigation the remainder is concerned largely with descriptions of a variety of works actually carried out. These include some unusual problems such as the isolation of foundations for forging hammers, the construction of harbours and jetties using large prefabricated members, and underpinning old and unstable structures. Many of the works mentioned have previously been described in periodicals. Most writers on soil mechanics, and the author of this book is no exception, appear to assume that nothing was known of the art of building foundations before devices appeared for extracting 2-in. cylinders of soil from the earth's crust; for example, the dangers due to shrinkage of clay following the extraction of moisture by trees growing nearby was commented on by authors of classical antiquity in terms as unequivocable as those used to-day by some Government departments. The book contains many photographs, but the relevance to the text of some does not appear obvious. However, the book is easy to read, and by its concentration on the description of some remarkable and ingenious foundations will possibly be as valuable to young engineers as many books in which an undue proportion of space is devoted to mathematical complexities.—J. E. G.

"**Analysis of Statically Indeterminate Structures.**" By J. I. Parcel and R. B. B. Moorman. (John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London. 1955. Price 76s.)

THIS book differs from many American works on the subject in that it is more complete and contains previously unpublished methods of analysing frames with side sway and with curved members such as multiple-arch structures.

The early chapters deal with the calculation of deflections by the method of virtual work, by the methods due to Castigliano, by moment-areas, and by "elastic" weights. Graphical methods, including the Williott-Mohr diagram, are also described. Continuous beams and frames are analysed by the theorem of three moments, slope-deflection, moment distribution, column analogy and the elastic-centre method. Consideration is given to members of varying moment of inertia. In the chapter on continuous trusses a method is given for the rapid determination of approximate stresses to enable reasonably correct proportions to be chosen for design. The method is applicable to trusses of two or three spans. The treatment of secondary stresses is sufficient for all structural engineering problems. Two-pinned and fixed arches are considered, but the treatment is largely confined to the mathematically elegant solutions for parabolic arches in which the moment of inertia varies in proportion to the secant of the angle of inclination of the axis with the horizontal; other arch curves may, in many circumstances, be more usefully adopted, but there is little advice on this matter. The last chapter is an extensive treatment of suspension bridges.

In all cases the methods are carefully and simply described, with many numerical examples set out in a manner suitable for use in an office. Where more than one possible method of analysis is available their advantages and disadvantages are discussed. The book can be recommended to anyone requiring a comprehensive treatment of the subject.—J. E. G.

"**Constructional Steelwork.**" By Oscar Faber, C.B.E. 360 pp. 1955. (London: E. & F. N. Spon, Ltd. Price 50s.)

ALTHOUGH primarily written for students and draughtsmen, this book, which gives much advice based on the author's experience, should also be useful to engineers in practice who are concerned with the design of buildings in structural steel. The work is profusely illustrated with clear drawings.

"**Civil Engineering Design Notes and Sketches.**" By T. W. Barber. Revised by Rolt Hammond. 272 pp. (London: Technical Press, Ltd. Price 25s.)

THIS work is a glossary of terms used in civil engineering and building construction, with the difference that the meanings of the terms are explained by outline sketches instead of by words.

A Large Air-conditioned Building.

COMPOSITE REINFORCED AND PRESTRESSED CONSTRUCTION.

A NEW processing building of interesting design for producing Terylene has recently been completed at Wilton, Middlesbrough, for Imperial Chemical Industries, Ltd. For reasons connected with the process it was essential to control humidity and temperature; complete air-conditioning was therefore specified, and no windows or ventilators were permitted. In each story air is introduced at ceiling level and withdrawn at floor level, passing in its course through the processing machines. and all the cables comprised twelve high-tensile wires of 0·2 in. diameter. After allowing for losses, it was estimated that each cable exerted a force of 22½ tons on the concrete.

An overall thickness of 6 ft. was specified for the first floor (*Fig.* 1), which accommodates, in addition to the structural members, two separate systems of air-conditioning ducts at right angles to each other and a number of service ducts extending the full length of the building.

Fig. 1.—Upper Story.

The production areas were designed for an imposed load of 1¾ cwt. per square foot. The three air-conditioning plant rooms, all at first-floor level, were designed for a load of 4 cwt. per square foot. Expansion joints are provided at intervals by twin columns and beams. The largest part of the structure between expansion joints is about 315 ft. by 130 ft.

The crushing strengths specified for the concrete were 5500 lb. per square inch at 28 days for prestressed concrete, 3750 lb. per square inch for thin shell roofs, and 3000 lb. per square inch for other parts of the structure. These specified crushing strengths were exceeded in all cases. The prestressing was by the Freyssinet system

A completely flat ceiling was required in the lower story so that a complex system of overhead runways could be fitted.

The spacing of the columns was determined by the arrangement of the machinery and resulted in the main beams, with a maximum span of 37 ft. 6 in., being placed at 42 ft. 1 in. centres. The arrangement of the machines that was necessary on the upper and lower floors made the spacing of the secondary beams a difficult problem and a compromise of 7 ft. 6 in. centres was agreed upon. The moderate spans of the slabs made it a simple matter to form the large number of access and service holes required. Cross sections are shown in *Fig.* 2.

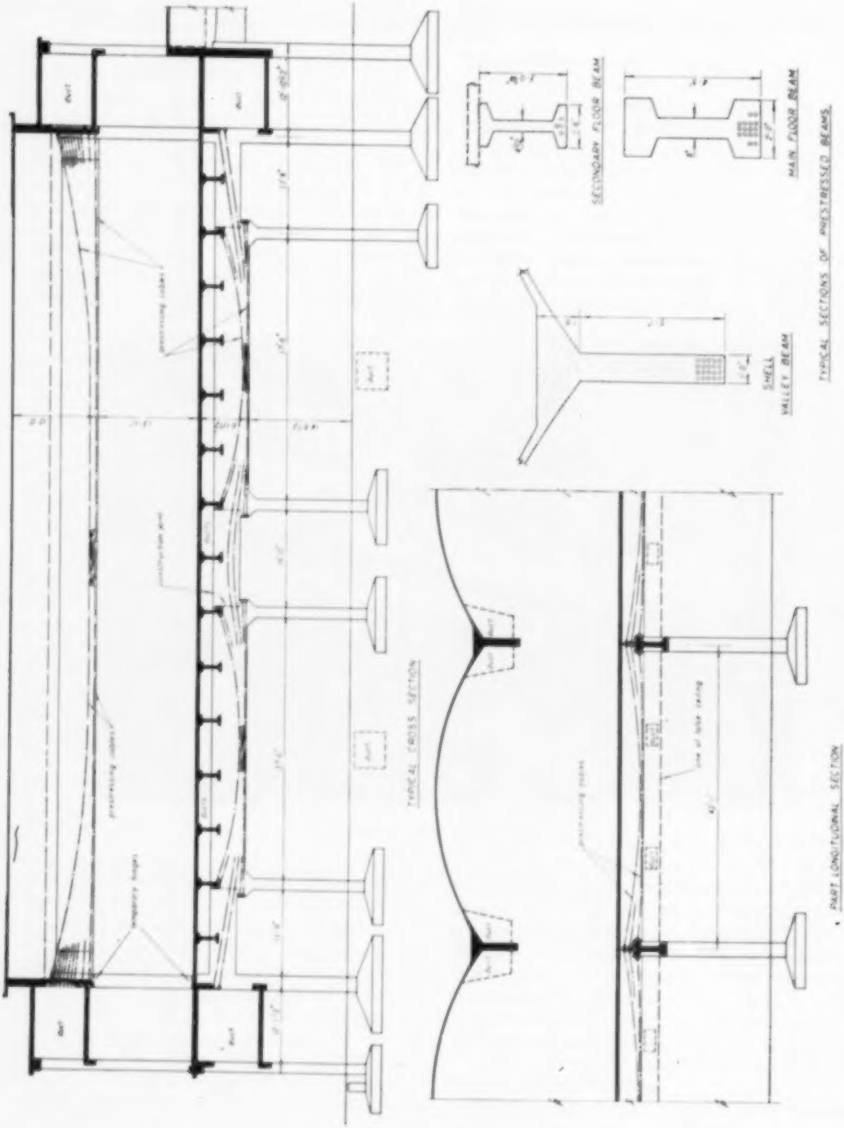


Fig. 2.—General Arrangement.

The first floor is 21 ft. 6 in. above ground-floor level and it was realised that a formidable amount of scaffolding would be needed to place all the concrete in situ. It was therefore decided to cast the floor slab and main beams in situ, and to precast the secondary beams. With the exception of the sides and ends of the building, where special problems arose, all the beams were prestressed.

Concurrently with the concreting of the columns and main beams, the secondary beams were cast in a herringbone plan on the ground floor. Reinforced concrete end-blocks containing the anchorage cones were cast first, followed by the central part containing the metal-sheathed cables and stirrups (*Fig.* 3). In this way the end-blocks, in which the highest stresses would occur, were cast a week or so earlier than the intervening portion, thus enabling the cables to be tensioned with the least possible delay. By the time the secondary beams were ready for lifting, the main beams were completed except for tensioning the prestressing cables. These beams were constructed in a similar manner. They were stripped of all shutters, but temporary props were left at the panel points.

After the secondary beams had been lifted into position by a mobile crane, some of the prestressing cables in the main beams were tensioned and the props removed. Shuttering was then fixed to span between the secondary beams, and concrete placed to form the floor slab. The secondary beams were designed to support this weight on their full span. When the slab had hardened it formed the compressive flange of a composite section to resist the superimposed load. Reinforcement was provided to help to bind the precast and in-situ concretes together.

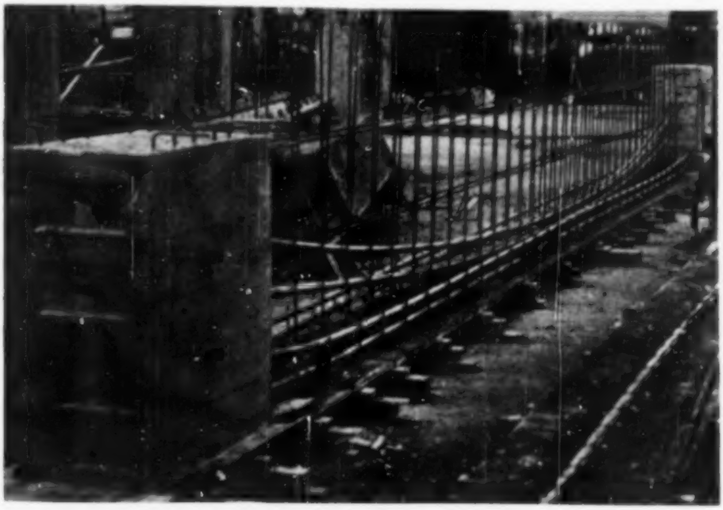


Fig. 3.—End Blocks and Cables in Position.

After placing the floor slab, the remaining cables in the main beams were tensioned.

The upper story was required to have no internal columns and was covered with a shell roof 3 in. thick, with a chord width of 42 ft. 1 in. and a span of 117 ft. 6 in. The valley beams were of prestressed concrete and, to allow for the consequent shortening, the columns at one side of the building were provided with temporary hinges which were subsequently grouted.

Much consideration was given to methods of construction whereby the maximum use would be made of prefabricated shutter units, and the sequence of construction was such as to allow use to be made of the structure for supporting subsequent work. The prefabricated shutters used for the barrel vault

consisted of units measuring 10 ft. by 40 ft. formed of resin-bonded plywood screwed to 6-in. by 2-in. timber bearers spanning pairs of timber trusses which were erected and lowered by four hand-winches mounted on the matured reinforced concrete beams and operated simultaneously. After lifting, the trusses were supported and positioned on cleats bolted to the sides of the valley beams, and the remaining fabric and bar reinforcement was then placed in the shell roof and connected to the bars projecting from the beams; the concrete was then placed for the roof. At least three complete shells were shuttered at one time, the first being stripped when the second had hardened sufficiently to resist the horizontal thrust. Tensioning of the prestressing cables in the valley beams was not commenced until the whole roof (six bays of 42 ft. 1 in.) had been completed.

Other work included a single-story production area of 36,740 sq. ft. covered with shell roofs similar to those described but spanning 88 ft., and single-story warehouses also covered with shell roofs but with valley beams in reinforced concrete over continuous spans of 63 ft. 6 in. and 69 ft. 6 in. Further extensions were added during the course of the work, using the same methods for floor and roof construction.

The reinforced concrete and prestressed concrete work were designed by The British Reinforced Concrete Engineering Co., Ltd., for the Chief Engineer, Imperial Chemical Industries, Ltd., Wilton Works, and constructed by Messrs. A. Monk & Co., Ltd.

Strength of High-alumina Cement in Hot Humid Atmospheres.

In the Report of the Building Research Station for the year 1954 (H.M. Stationery Office. Price 4*s*.) it is stated that an investigation is being made into the decrease in strength of high-alumina cement in one of its applications in the electrical industry. This cement suffers a marked loss in strength if maintained in a humid atmosphere at temperatures above normal, and the investigation has been directed to a study of the mineralogical changes associated with this loss in strength.

It has been established that the first compound formed on hydration of high-alumina cement is $CaO.Al_2O_3.10H_2O$, and that it is this substance which gives the high early strength. The compound is not stable in warm moist conditions and undergoes a chemical change as follows:

$$3(CaO.Al_2O_3.10H_2O) = 3CaO.Al_2O_3.6H_2O + 2Al_2O_3.3H_2O + 6H_2O.$$

This reaction is always associated with the decrease in strength of set high-alumina cement cured under warm conditions. Attempts have been made to stabilise the $CaO.Al_2O_3.10H_2O$ by chemical additions, but so far without success.

It is suggested that it might be possible to modify the composition of the cement to produce a more stable hydrated compound that would contribute equally well to the early strength of the cement.

Concreting in Winter.

Full details are now available of the Symposium on "Winter Concreting: Theory and Practice," to be held in Copenhagen in February 1956 under the auspices of the Danish Union of Testing and Research Laboratories of Materials and Structures (RILEM). A brochure giving these details is available (printed in the English language) from the Secrétariat Général, Laboratories du Batiment et des Travaux Publics, 12 rue Brancion, Paris XVe, France.

Arches for a Bridge Cast Vertically.

THE first stage in the construction of a reinforced concrete bridge over the Storms river gorge, 110 miles from Port Elizabeth, South Africa, was completed in August. The bridge was designed by Professor Ricardo Morandi, of Rome, for erection by a method that he has used for bridges in Italy and Venezuela in which the bridge is cast vertically in the form of half-arches which are lowered towards each other to form the completed arch. The gorge is 330 ft. wide and 400 ft. deep.

An open-spandrel reinforced concrete arch bridge was designed by the Cape Province Roads Department, but in view of the high cost of falsework it was decided to invite tenders for a bridge in reinforced concrete, prestressed concrete, structural steel, or aluminium alloy. Twelve tenders were received varying from £91,240 for a continuous steel-plate girder to £174,300 for an aluminium truss. The second lowest tender was a reinforced concrete fixed arch using Professor Morandi's method of construction at a cost of £92,109. This tender, submitted by Concor Construction Corporation (Pty), Ltd., of Johannesburg, was

Fig. 1.

Fig. 2.

accepted because of the saving in maintenance costs.

The design consists of four arch ribs connected in pairs, with top and bottom slabs to form a box-girder supporting spandrel columns sloping at 15 deg. from the vertical away from each other on either side of the crown. The columns on the banks slope at 15 deg. from the vertical, but in the opposite direction to those on the half-arch nearest to the bank, thus forming, in conjunction with the deck structure carried by them, a series of trestles. The inclined spandrel columns are claimed to reduce considerably the stresses in the arch ribs.

The first 40 ft. of the arch ribs were constructed on staging built up from the ground. Each half of the remainder of the span (250 ft.) was then built nearly vertically in two parts each comprising a pair of ribs (*Fig.* 1). The ends of the 40-ft. sections were supported on a temporary concrete trestle, which also carried the steel hinges and the vertical-standing parts of the arch. The four hinges at each end were connected together in pairs, and a telescope was mounted on the connecting member. By rotating the hinges with the telescope in position it was possible to simulate the action of the arch ribs during lowering and thus to fix the exact lines to which they must be constructed to ensure that they would be in the required position when they were lowered. A hinge is shown in *Fig.* 2.

Tubular steel staging was then erected on the temporary trestles and supported against the part of the deck already constructed. The concrete in the ribs was then cast up to a point that would be 1 ft. 9 in. short of the crown of the finished bridge, and braces were constructed between the pairs of ribs. Lugs were cast into the ribs, and cables from these pass through pulleys and over derrick booms 76 ft. high mounted on the deck, and thence to hand winches of

Fig. 3.

3 tons capacity secured to concrete blocks at each end of the structure.

The method of lowering was briefly as follows. On the first day hydraulic jacks were inserted at deck level to exert a pressure of 8 tons on each half-arch, which had a vertical height of 127 ft. 1 in. and weighed 90 tons. The ribs were pushed over sufficiently to start their movement by gravity, after which the cables and winches took the strain. The ribs were rotated through an angle of 21 deg. (*Fig.* 3), when the rotation was stopped and prestressing cables, already fitted to the outside of the arch ribs, were tensioned to 65,000 lb. per rib to prevent tensile stresses in the ribs during the remainder of the lowering operation. The ribs were left in this position overnight, and on the following day the ribs were first lowered towards each other in stages of 10 deg. and then in stages of 1 deg. The speed of lowe ing was about 1 deg. in seven minutes. On reaching their final position (an angle of rotation of 80 deg.), there was a gap of 3 ft. 6 in. between the ends of the ribs at the crown, and in this gap steel joists were fitted between steel plates previously cast in the ends of the ribs. The joists were concreted in, the prestress was released, and the cables removed. The structure was then a three-hinged arch. The slabs over and under the ribs will next be cast, after which the hinges will be concreted in, rendering the structure a fixed-ended arch. The spandrel columns and the deck over the arch will then be built and the temporary trestles demolished.

The dimensions of the completed bridge will be as follows. Overall length, 628 ft. 6 in.; rise of arch, 66 ft.; roadway, 22 ft. wide with footpaths 2 ft. wide; height of road above river bed, 405 ft.; total length of arch, 372 ft. The total amount of concrete in the bridge is 2400 cu. yd. and the weight of steel 350 tons.

[During the last war the Royal Engineers built several timber bridges of considerable span by the method of erecting half-arches vertically on the banks of rivers.]

Design Assumptions and the Behaviour of Prestressed Concrete.

Dr. P. W. Abeles writes:

In my article in the September number of this journal, under the heading "Factor of Safety against Cracking," a minimum compressive stress in the concrete of 200 lb. per square inch is given on page 321 as the required stress under working load to ensure a factor of safety of 1·2 against cracking (or, better, against the opening of cracks). This relates to a prestressed structure in which the tensile resistance of the concrete is not available and the tensile stress due to live load amounts to 1000 lb. per square inch. The effective prestress in the concrete would therefore have to be 1200 lb. per square inch before the live load is applied.

The corresponding effective prestress in the concrete required in a truly monolithic prestressed structure with well-bonded wires need be only 200 lb. per square inch for the same factor of safety of 1·2 and for the same live load on the assumption that the modulus of rupture amounts to 1000 lb. per square inch. The permissible tensile stress in the concrete under working load would therefore be 800 lb. per square inch. The stress of 670 lb. per square inch mentioned on page 321 corresponds to a larger range of the stress due to live load (1670 instead of 1000 lb. per square inch) for the same factor of safety against cracking, and would allow freedom from cracks under fatigue conditions.

Prestressed Roof Beams of 123 ft. Span.

NOVEL METHOD OF CONSTRUCTION.

IN a new factory being built at Pennyburn in Northern Ireland for the Ministry of Commerce the main production area is required to be 123 ft. square and 17 ft. high without intermediate supports. Provision will be made at one end for future extension.

On one side of the building the reinforced concrete columns are carried on bases that extend down to boulder clay. On the other side, where the clay lies deeper, the columns are carried on precast concrete piles. Hinges are provided in the columns as shown in *Fig.* 1. The roof is made of asbestos-cement cavity decking with patent glazing and ventilators.

The main beams resemble steel-plate girders. The specification required the concrete to have a cube strength at 28 days of not less than 6250 lb. per square inch. The beams were designed for a maximum compressive stress due to prestressing of 2000 lb. per square inch. The beams were designed so that there will be no tensile stresses when they are subjected to full live load, and 1000 lb. per square inch compression in the top flange.

The main beams are 8 ft. 9 in. deep at the centre and 6 ft. 6 in. at the ends. They are prestressed with three Macalloy bars on each side of the 3¾-in. web. The bars are protected by paint, and after erection are encased in concrete. The top flange is 3 ft. 6 in. wide at the centre. The precast diaphragms are set up first as shown in *Fig.* 3, and the web and bottom flange are cast next, the top flange being left until later to avoid the risk of horizontal shrinkage cracks.

After prestressing, the beams (which weigh 46 tons each) are supported from a temporary gantry by steel lifting-straps attached to pins passing through the end blocks. The straps are perforated at close intervals as shown in *Fig.* 2. The beams are raised by hydraulic jacks in stages, and when at the required level are moved sideways and lowered on to the columns (*Fig.* 4).

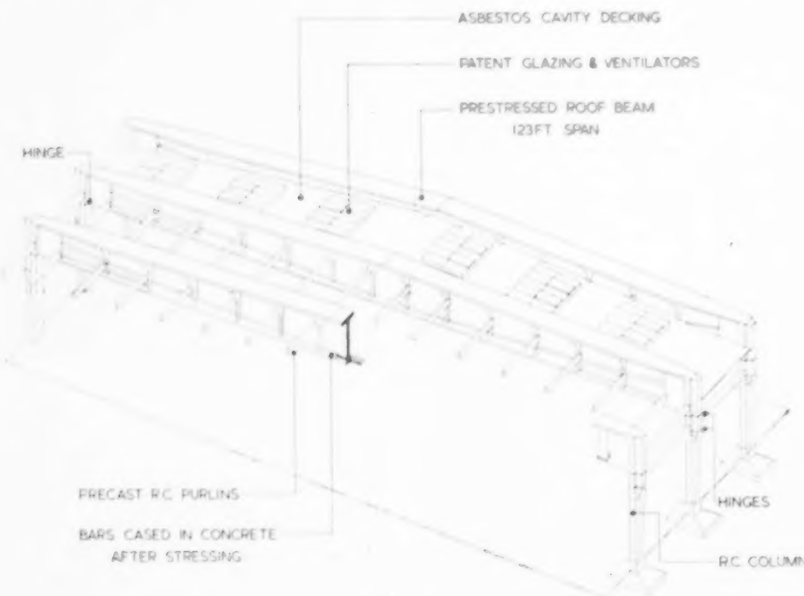


Fig. 1.

Fig. 2.

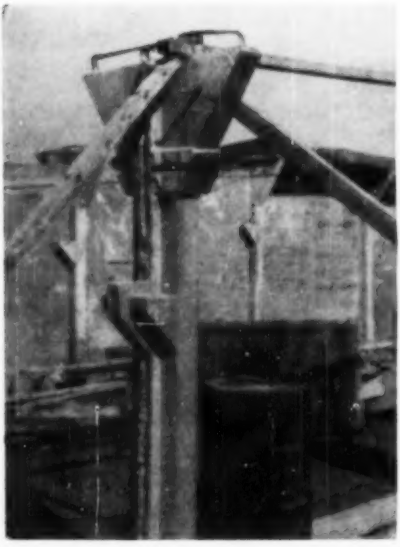


Fig. 3.

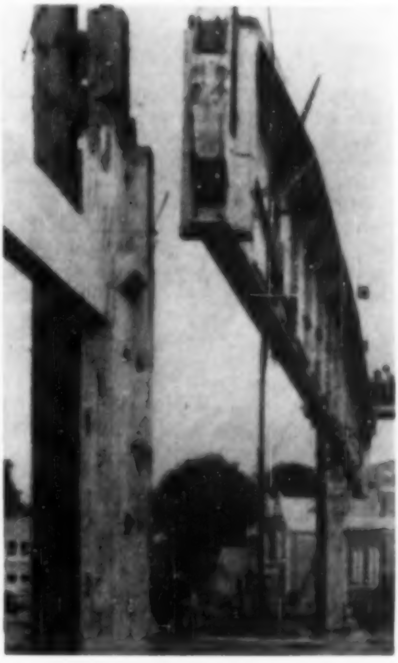


Fig. 4.

Congress on Prestressed Concrete.

PROFESSOR EDUARDO TORROJA* (Spain) has been elected Deputy General Vice-President of the Fédération Internationale de la Précontrainte in succession to the late Professor Gustave Magnel. Professor Torroja is Professor of Civil Engineering at the Instituto Tecnico De La Construccion Y Del Cemento (Madrid), Doctor Honoris Causa of the Politeknicum (Zürich) and of the Universities of Buenos Aires and Chile, member of the Royal Academy of Science (Madrid), and technical adviser and member of the Executive Committee of the International Association for Bridge and Structural Engineering.

Mr. P. Gooding, Secretary of the Prestressed Concrete Development Group (London), was elected Secretary and Treasurer in succession to Monsieur J. A. Prempain (France).

The following is a list of the papers read at the Congress of the Federation held in Amsterdam last month.

Function of Grouting and Anchorages in the Behaviour of Prestressed Elements (General reporter, B. Kelopuu): The role of grouting, by G. Magnel; The "Barredo" system, by Riccardo Barredo; Facts about grouting, by the STUVO Committee; The grouting of cable ducts, by J. J. B. J. J. Bouvy; Failure tests on statically-determinate prestressed beams: the role of grouting and anchorages up to failure, by Ugo Rossetti; The anchorage in the Dywidag system and its significance, by Dyckerhoff & Widmann KG.; Recommendations for end-anchoring systems, by the STUVO Committee; Practice regarding grouting and anchorages in Great Britain, by A. W. Hill.

Manufacture and Use of Steel for Prestressing (General reporter, A. S. G. Bruggeling): Results of tests, by Franco Levi; User and producer difficulties, by C. F. Brereton; Problems from the users' point of view, by J. J. B. J. J. Bouvy; Creep tests, by G. M. Canta; Research on optimum tension, by P. Xercavins; Steel for prestressed concrete, by André Millot.

Precast Work in the Factory and the Assembly by Prestressing on the Site (General reporter, D. H. New): Composite structures, by W. J. P. Pelle and A. S. G. Bruggeling; Site assembly of precast units, by G. Magnel; Three-pin frames in two Finnish industrial buildings, by Ali Sandstrom; Assembly of continuous beams from precast units, by Jacques Robin; Hangar at Helsinki airport, by O. Tormanen, H. Kakko, A. Sallinen, and M. Janhunen; Calculation of structures assembled from precast units, with particular reference to shrinkage and creep, by Hermann Ruhle; Some considerations on precasting, by Thierri Jean-Block; Progress in Great Britain, by D. H. New; Non-industrial structures, by J. Barets; Method of assembling precast beams into continuous structures, by J. J. B. J. J. Bouvy; New apparatus for stressing two wires simultaneously in the long-line process, by J. F. Herbschleb and A. Komijn; Precast prestressed canals, by C. Leontieff; Continuous prefabricated prestressed bridge in Amsterdam, by G. F. Janssonius and G. Scherpbier.

Moment Distribution in Statically-indeterminate Prestressed Structures beyond the Elastic Phase (General reporter, Y. Guyon): Moment distribution in statically-indeterminate structures beyond the elastic phase, by G. Magnel; Experimental study of continuous prestressed beams in the plastic state and up to failure, by Gigio Macchi; Research in Great Britain on moment redistribution on continuous beams, by P. B. Morice; Determination of the moment-curvature relationship for a rectangular beam, by Y. Guyon.

Influence of Plasticity on the Strength and Instability of Prestressed Thin Shells (General reporter, Franco Levi): Research on a north-light shell structure, by A. M. Haas.

Comparative Analysis of Specifications and Practice in Prestressed Concrete in various Countries, by A. Paduart.

The Economical Advantages of Prestressed Concrete in various Countries, by A. W. Hill.

Lectures on Roads.

LECTURE courses on the design and construction of concrete roads will be held at the Road Research Laboratory, Harmondsworth, during the autumn and winter of 1955–56. Full particulars can be obtained from the Director, Road Research Laboratory, Harmondsworth, Middlesex.

Repairing a Lighthouse.

SKERRYVORE lighthouse stands on an isolated rock about sixty miles west of Oban, Argyllshire, and eleven miles southwest of the island of Tiree in the Inner Hebrides. It was built by Alan Stevenson (an uncle of R. L. Stevenson) for the Northern Lighthouse Board between 1838 and 1844. It is built of granite throughout and is 150 ft. high and 42 ft. diameter at the base. In March, 1954, the tower was gutted by fire and the masonry was damaged, mainly due to the mica content of the granite swelling in the intense heat. Externally there were some cracks right through the wall, and internally there was much flaking and spalling of the granite. Some of the damage at the top was due to blast from the fog-signal charges. During the summer of 1954 temporary repairs were carried out by the staff of the Lighthouse Board and the building made reasonably watertight.

Meanwhile tenders were invited for permanent repairs, and in January, 1955, the scheme put forward by Messrs. Whitley Moran & Co., Ltd., was adopted. The internal walls of the rooms have been repaired by cutting out damaged granite and replacing it with gunite. The domed ceilings have been restored by forming thin gunite domes on the underside. No steel reinforcement was allowed owing to the danger of corrosion. The cracks in the tower were filled by pressure-grouting with neat cement; it was not necessary to take down and rebuild any of the masonry.

The rock on which the lighthouse is built lies in a large area of shoal water, and the approaches are hazardous when there is any swell and impossible in bad weather. There is no beach or landing stage, and no sheltered place where plant could be safely set up and materials stored. The only accommodation available for men was in the lighthouse, and this was intended to house only four men. The work was divided into two main phases, namely the preliminary and the permanent work. The preliminary work included the construction of bases for a crane and compressor house; the supply and erection of a 3-tons hand-crane designed so that it could be transhipped in small components and put ashore from an open boat; the provision of a steel hut, designed like the deck-house of a ship, and built up of small units, to house a compressor; the erection of a small timber landing stage; and various minor works. The crane and compressor-house were supplied by the main contractor, but the bases and erection were carried out by Messrs. D. & J. McDougall, of Oban, during March to May 1955. Bad weather delayed work on several occasions for a week at a time.

The permanent repair work comprised the guniting and pressure-grouting; these were started at the end of May and completed in September. The internal gunite work was completed first during June and July. The external guniting and pressure-grouting were done from suspended cradles with the aid of steeplejacks. There were seven men on the rock, comprising six contractor's men and one lightkeeper. Oban was the main base of operations, with an advanced base at Hynish in the island of Tiree, where there is a small pier. Transport of men and equipment by sea was mainly done by the Northern Lighthouse Board's m.v. "Hesperus". A small coaster was used to take out the heavy plant in May, and the motor fishing boat "Monsoon", owned by

Mr. H. Carmichael, of Mull, was chartered for the day-to-day supplies of materials, provisions, and water from Hynish to the rock.

The radio-telephone at the lighthouse was linked to the Post Office marine radio telephone system at stated times, so that it was possible to speak to the men at the rock from Edinburgh or Liverpool. For local communications, V.H.F. radio telephony was installed in the lighthouse, on the service fishing vessel, and the base at Hynish, so that advantage could be taken of landing supplies when wind and sea conditions allowed.

The whole of the repair work was completed towards the end of August, 1955, and the weather broke immediately afterwards. The temporary landing stage was swept away and the crane slightly damaged. By making use of calm spells the heavy plant was loaded piecemeal into the fishing vessel and safely transferred to Oban. The weather worsened and the withdrawal of the men became a matter of urgency as food supplies were getting short. After standing by for three days, m.v. "Hesperus" successfully took the men off on September 5 in rather heavy seas.

Lightweight Prestressing Equipment.

A NEW prestressing equipment for tensioning single wires has been produced by P.S.C. Equipment, Ltd. The pump and pressure-gauge are contained in a box (*Fig.* 1), and the jack (*Fig.* 2), which weighs only 7 lb., is fitted with a swivel that allows the flexible oil-tube to rotate under pressure. The anchorage comprises a split sleeve which, when pushed into a tapered hole, secures the wire. If the amount of extension required exceeds the capacity of the jack, the jack is released, refixed close to the anchor, and the wire further extended. The equipment is at present available for wires of 0·276 in. diameter, and is suitable for use in the pre-tensioning and the post-tensioning processes. The jack is attached to the wire by a quick-release grip, and provides a quick means of tensioning wires.

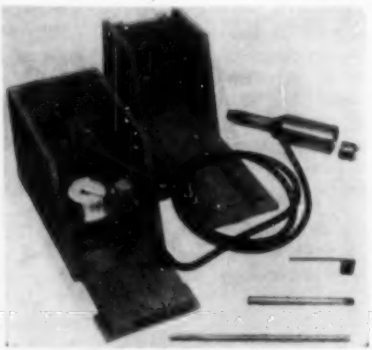


Fig. 1.

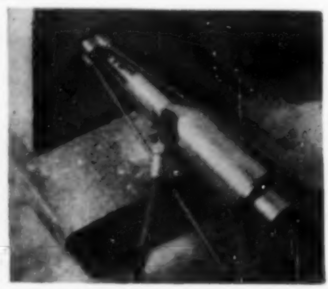


Fig. 2.

Design of Non-prismatic Members.

MR. A. J. ASHDOWN writes as follows.

Referring to Mr. H. P. Vaswami's article on "The Design of Non-prismatic Members" in the August, 1955, number of "Concrete and Constructional Engineering," it may be of interest to recall my article in your journal for March, 1932, where the use of Simpson's rule was employed for the determination of characteristic points in beams with varying moment of inertia.

I may perhaps mention that the $\frac{1}{I}$ diagram for the non-prismatic member in Mr. Vaswami's example is not a straight line for a linearly-increasing depth; that this is not so will be readily seen since I varies as d^3. If, in example 1, the middle value of I for beam BC be corrected for a linearly-varying depth as drawn in *Fig.* 3, the final distribution factors will be altered to 0·43 and 0·57 for BA and BC respectively.

Some views of the open-air swimming pool at the Skegness Holiday Camp.
By kind permission of Messrs. Butlins Ltd.

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Design of Gravity and Arch Dams.

THE following notes are abstracted from a paper by Mr. J. J. Hammond (chief of the Dams Branch of the U.S. Bureau of Reclamation) published in a recent number of the Journal of the American Concrete Institute.

Dams should be designed only for combinations of loading that have a reasonable chance of occurring at the same time. The factors of safety should not be excessive, and the design should be checked for stability under assumed extreme conditions of loading using smaller factors of safety. In addition to the general factors of safety, the designer may be tempted to include additional allowances due to the over-conservative treatment of uncertainties. Structures so designed may possess margins of safety in excess of the designer's intent and are uneconomical. Factors of safety should provide for all underlying uncertainties and should be used without additional provision for safety, except under conditions involving unusual uncertainty. Additional factors commonly result from the use of approximate or conjectural data. Data used in design should be the most specific and accurate available, and whenever possible should be based on tests or measurements made of existing structures. When such data are not available the best data obtainable by conservative approximation or judgment should be used without further adjustment by reason of uncertainty.

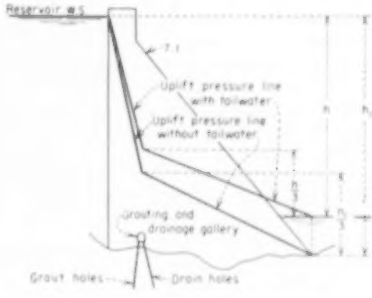

Fig. 1.

Forces Causing Instability.

RESERVOIR AND TAIL-WATER LOADS.—These loads may be accurately calculated. They tend to promote sliding, shearing, overturning, and crushing and also are the source of uplift pressures. Conditions due to normal water level and maximum flood water level, with the corresponding tail-water levels, should be considered. These forces should be considered to act normally to the contact faces of the dam.

UPLIFT.—This is one of the most important forces on gravity dams and is usually unpredictable. Precautions should be taken for measuring and controlling uplift, and maintaining drainage. Uplift forces are caused by water entering the pores, cracks, joints, and seams in the concrete and the foundations. If this pressure should rise above a predetermined amount, additional drainage should be installed. Because of the low permeability of good concrete and the effect of face drains, water in the pores probably does not penetrate deeply into a dam during its useful life, except through cracks. However, from observations of existing structures it may be deduced that uplift pressures should be considered to act throughout the dam and its foundation. Because of their transitory nature earthquake forces are assumed not to affect uplift pressures. In arch dams uplift pressure is usually unimportant.

For the preliminary design of gravity dams, the uplift pressure should be assumed to have an intensity at the line of drains that exceeds the tail-water pressure by one-third of the difference between the head-water and the tail-water pressures. The pressure gradient falls uniformly from this amount to the tail-water pressure at the toe of the dam and increases uniformly to the head-water pressure at the upstream face of the dam (*Fig.* 1). The pressure should be assumed to act over the whole of the area of the foundations. For the final design of gravity dams, the pressure distribution should be similar to that used in the preliminary design, but the pressure at the line of drains should be based on the assumptions that the drains are working and that the grouting of the foundation does not affect the pressure distribution significantly. To check the stability of gravity dams under extreme loading conditions when the drains are choked, the uplift pressure should be assumed to be the full reservoir pressure at the upstream

face varying linearly to the tail-water pressure at the downstream face. If the uplift pressure exceeds the normal vertical pressure (computed without uplift) at the upstream face, then a horizontal crack should be assumed to exist extending from the upstream face into the interior of the dam to the point where the normal vertical pressure (assuming a linear distribution without uplift) is equal to the reservoir pressure at that level. Uplift pressure for this condition should be assumed to be the full reservoir pressure extending from the upstream face to the end of the crack and from there varying linearly to the tail-water pressure at the downstream face.

For the design of arch dams uplift should not be considered except in cases where the tensile stresses are such that the concrete will crack; after the concrete has cracked normal uplift pressures should be assumed.

EARTHQUAKES.—Earthquake accelerations may increase the pressures of the water and silt on the dam and stresses within the dam. Some of the factors affecting these pressures and stresses are not completely understood. Accordingly, an allowance is made for the effects of increased pressures, and an additional allowance is made to account for the horizontal and vertical forces the earthquake acceleration imparts to the dam. Analyses of the effects of resonance may be required in designing appurtenant structures. Experiments and analyses show that an earthquake acceleration of up to about 0·3 gravity (9·6 ft. per second per second) is only about one-half as effective in silt or soil as in water. This is due to the resistance to shearing forces offered by the silt. Since the unit weight of water is also about half that of silt, it should suffice to determine the increase in silt pressure due to earthquakes as if the water extended to the base of the dam. This increased pressure should be added to the static silt pressures.

Earthquake loading should be selected after consideration of horizontal and vertical accelerations which, from records, may reasonably be expected at each site. For dams with vertical or sloping upstream faces, the hydrodynamic pressure due to horizontal movement caused by earthquakes varies with the depth and is given by the equations

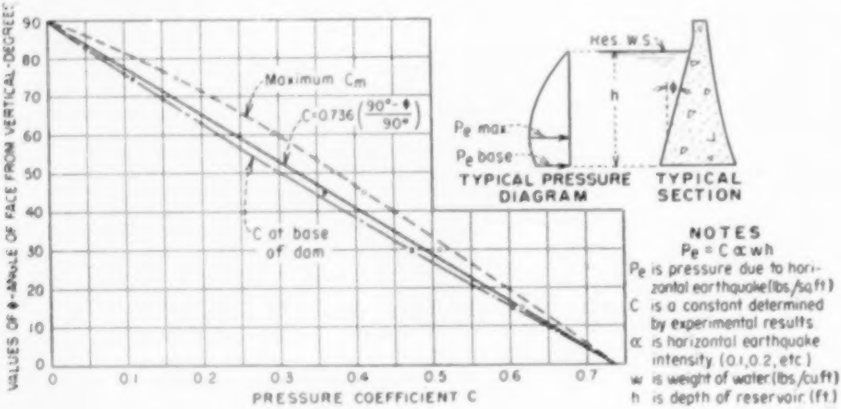

Fig. 2.

$$P_e = C\alpha w h \quad . \quad . \quad . \quad . \quad (1)$$

and

$$C = \frac{C_m}{2}\left[\frac{y}{h}\left(2 - \frac{y}{h}\right) + \sqrt{\frac{y}{h}\left(2 - \frac{y}{h}\right)}\right] \quad (2)$$

where P_e = pressure normal to the dam face (lb. per square foot);

α = the earthquake intensity $= \dfrac{\text{earthquake acceleration}}{\text{acceleration due to gravity}}$;

w = unit weight of water (lb. per cubic foot);

h = maximum depth of reservoir (ft.);

y = vertical distance from the reservoir surface to the level being considered (ft.);

C_m = dimensionless pressure coefficient (the maximum value of C for a given slope can be obtained from *Fig.* 2).

For dams with a partly vertical and partly sloping upstream face, if the height of the vertical portion of the face is equal to or greater than half the total height the pressure should be calculated as if the face were vertical throughout; if the vertical portion is less than half the total height of the dam, the pressure should be calculated on a sloping line connecting the point of intersection of the face of the dam and the reservoir surface with the point of intersection of the face of the dam and the foundation. For vertical movement caused by earthquakes the component of water pressure normal to the face of the dam should be modified by an appropriate acceleration factor and the unit weight of concrete should be modified by the same acceleration factor.

Ice Loads.—Existing information on ice pressure is inadequate and somewhat approximate and the present analytical procedures should be used only as a guide to the magnitude of ice pressures. Ice pressure is caused by thermal expansion of ice and by wind blowing over the frozen surface. Ice loads are usually transitory.

Silt Loads.—Available data on silt pressures are inadequate and scarce. Not all dams will be subjected to silt pressure, and available hydrological data should be studied to ascertain whether or not an allowance for silt pressure is appropriate. The horizontal pressure of silt should be considered as equivalent to that of a fluid having a density of 85 lb. per cubic foot. The vertical silt pressure should be determined as for a soil having a wet density of 120 lb. per cubic foot; the magnitude of this pressure varies directly with depth.

Forces Causing Stability.

Dead Load.—The weight of the concrete should be assumed to be 150 lb. per cubic foot for preliminary designs but for the final design its weight should be more accurately determined. The distribution of dead load should be related to the construction procedure, with consideration of secondary stresses due to temperature changes. It should be assumed that shear stresses are not transmitted across ungrouted longitudinal or circumferential joints.

Resistance to Shearing Forces.—The resistance to shearing forces that exist within a dam and its foundation, and between a dam and its foundation, are due to the cohesion and internal friction inherent in the materials and at their points of contact. Resistance to shearing forces may be expressed, with sufficient accuracy, by the equation

$$\tau = C + \sigma_n \tan \phi \qquad (3)$$

where τ = shear resistance (lb. per square inch); C = cohesion (lb. per square inch); $\tan \phi$ = coefficient of internal friction; σ_n = resultant normal pressure (lb. per square inch). Values of C and $\tan \phi$ are different for different materials and can be determined only from experiments.

The friction factor Q is defined as

$$Q = \frac{CA + N \tan \phi}{H} \qquad (4)$$

where C = cohesion; A = area of the base considered; H = summation of the shear forces; N = summation of the normal forces; $\tan \phi$ = coefficient of internal friction.

The friction factor is concerned with security against sliding or shearing at any section. Equation (4), with values for the loads and the resistances, applies to any section of the structure or its foundation. Modifications of this equation may be required to investigate special conditions within the foundation but the minimum factor will be the same for all cases unless highly unusual circumstances dictate otherwise. These considerations apply specifically to gravity dams. In special cases it may be desirable to determine the over-all shear resistance of an arch dam. For both gravity and arch dams the friction factor as given by equation (4) should not be less than 4 for normal loading conditions, and for gravity dams designed for the extreme loading condition should be sufficient to ensure stability. For preliminary designs, the values for cohesion and internal friction should be the most reasonable that can be selected on the basis of known values of similar or comparable materials; for the final design, the values for cohesion and internal friction should be determined by tests.

Allowable Stresses and Strength of Concrete.—The strength of the concrete should be determined by tests on

specimens cured in sealed containers at temperatures similar to those expected in the structure, and 80 per cent. of all test values should exceed the strength required. The concrete should be strong enough to carry construction loads, and at one year should have a strength at least four times the allowable working stress; in no case should the allowable working stress exceed 1000 lb. per square inch.

COMBINATIONS OF LOADINGS. — The combinations of loads in the design should include only loads which have a reasonable probability of occurring at the same time, but the design should be made for the most adverse combination of such conditions. Combinations of transient loads which have only remote probability of occurrence at any given time have even less probability of simultaneous occurrence, and cannot be considered as reasonable bases for design. The design of gravity dams should be based on the most adverse of the combinations of load A, B, and C. The design should then be checked against the extreme combination of load D (see next paragraph).

The design of an arch dam should be based upon the most severe combination of normal loads, excluding normal uplift unless special considerations dictate otherwise. The normal combinations of forces to be resisted are the effects of: (A) Normal water pressure, ice, silt, and normal uplift; (B) Normal water pressure, earthquake, silt, and normal uplift; (C) Maximum flood-water pressure, silt, and normal uplift. The extreme load condition is D, maximum flood-water pressure, silt, and uplift pressure when the drains are blocked. The conditions when the reservoir is empty and when no allowance is made for resistance to earthquakes should be considered in calculating the amounts of reinforcement required.

OVERTURNING OF GRAVITY DAMS.— Before a gravity dam can overturn other failures may take place. For instance, the material in or against the toe of the dam may be crushed and cracking of the upstream face of the dam may occur and be accompanied by increases in uplift pressure and reductions of resistance to shear. Earthquakes, because of their oscillatory nature, need not be considered as contributing towards overturning.

Lectures on Building.

THE following lectures have been arranged by the Ministry of Works. Admission is free.

An Introduction to Prestressed Concrete, by R. C. Blyth. Technical Institute, Southway, Bognor Regis. October 12, 7 p.m.

The Thermal Insulation of Buildings, by J. Lawrie. Bull & Royal Hotel, Preston. October 12, 7 p.m.

Problems of Plastering and Rendering, by L. A. Ragsdale. Technical College, Lichfield Road, Southtown, Great Yarmouth. October 19, 7.30 p.m.

Introduction to Programming and Progressing for Builders, by A. E. Chittenden. College of Further Education, Newtown Road, Hereford. October 19, 7.15 p.m.

Typical Building Accidents—their Cause and Prevention, by J. A. Hayward. Crown & Anchor Hotel, Westgate Street, Ipswich. October 24, 8 p.m.

Lightweight Concrete, by H. A. Hodson. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. October 25, 7 p.m.

Concrete Placing and Formwork, by A. B. Harman, College of Technology, Anglesey Road, Portsmouth. October 25, 7 p.m.

Dampness in Buildings, by J. P. Latham. Ministry of Works, Ashley Street, Birmingham, 5. October 25, 7.15 p.m.

The Building (Safety, Health, and Welfare) Regulations (1948). Technical College, Wulfruna Street, Wolverhampton. October 26, 7.15 p.m.

Field Maintenance of Builders' Plant, by J. Stafford. Technical College, St. George's Gate, Doncaster. October 26, 7.15 p.m.

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 3d. a word : minimum, 7s. 6d. Situations Vacant, 4d. a word : minimum, 10s. Other miscellaneous advertisements, 4d. a word : 10s. minimum. Displayed advertisements, 30s. per column inch. Box number 1s. extra. The engagement of persons answering these advertisements is subject to the Notification of Vacancies Order, 1952.

Advertisements must reach this office by the 23rd of the month preceding publication.

SITUATIONS VACANT.

SITUATIONS VACANT. The Trussed Concrete Steel Co., Ltd., have vacancies in their London, Birmingham, Glasgow, and Manchester offices for reinforced concrete designers and detailers. Five-days' week. Pension scheme. Apply, giving full particulars of age, education, and previous experience, to the Secretary, Truscon House, 35–41 Lower Marsh, London, S.E.1.

SITUATIONS VACANT. Consulting structural engineers, Westminster, require first-class designer-draughtsman and a detailer experienced in reinforced concrete and/or steel framed buildings and foundations. High salaries and good prospects for suitable applicants. Write in confidence stating age, qualifications, and details of experience. Box 4167, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Designer-draughtsmen required for London head office of old-established reinforced concrete engineers. Applicants must be familiar with design of reinforced concrete frames and all forms of reinforced concrete floor construction. The post is permanent, progressive, and pensionable. Existing holiday arrangements would be respected. Write Box 4170, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Senior reinforced concrete designers wanted by leading reinforced concrete engineers and contractors. Must be fully conversant with Code of Practice, L.C.C. Bye-Laws, and able to design light-framed structures from estimating stage to final details. Five-days' week. Pension scheme. Progressive position. Starting salary from £900 upwards according to ability. This year's holiday arrangements honoured. Juniors also required, similar conditions. Write Box 4172, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete engineers require detailers and junior draughtsmen. Write, giving age, experience, and salary required to Considere Constructions, Ltd., 72 Victoria Street, London, S.W.1.

SITUATIONS VACANT. Air Ministry, Works Designs Branch, require in London structural engineering designer draughtsmen for reinforced concrete or structural steelwork with sound technical training, and several years' varied experience in design detailing of: (a) reinforced concrete construction for all types of buildings, or (b) steel-framed sheds, warehouses and similar buildings. Salaries up to £850 per annum, starting pay based on age, qualifications, and experience. Paid overtime. Posts non-pensionable with long-term possibilities. Natural born British subjects only. Write, stating age, qualifications, employment details, including type of work done, to any Employment Exchange, quoting Order No. BOROUGH 2304.

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SITUATIONS VACANT. Reinforced concrete designer-draughtsmen and detailers required by Ashmore, Benson, Pease & Co., Stockton-on-Tees. Must be fully experienced in either designing or detailing reinforced concrete structures, foundations and other civil work. Maximum assistance given in obtaining accommodation. Pension scheme, technical library, and sports facilities available. Apply, stating age, experience, etc., quoting reference "D", to Staff Personnel Officer.

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Invite applications for the following technical staff vacancies in their Research and Development Department, Boreham Wood, Herts:

SENIOR CHEMIST.
Honours Graduate or A.R.I.C. with research experience and an interest in physical and inorganic chemistry with an engineering basis.

ASSISTANT CHEMIST.
As above, but intermediate qualification will be accepted.

SENIOR CONCRETE ENGINEER.
Graduate or A.M.I.C.E. with an interest and ample practical experience in concrete technology. Post-graduate studies in this subject are desirable but not essential.

ASSISTANT CONCRETE ENGINEERS.
As above but qualifications are not essential.

SOILS ENGINEER A.M.I.C.E.
With a good theoretical and practical background in soil mechanics. Post-graduate studies in this subject are desirable but not essential.

EXPERIMENTAL ASSISTANTS.
Engineering degrees and qualifications are not essential, but applicants must be adaptable and ready to tackle a wide variety of experimental and research work.

ASSISTANT PLANT DEVELOPMENT ENGINEER.
Graduate in Civil Engineering, but with a mechanical bent, or vice versa.

MECHANICAL DRAUGHTSMEN.
For work on plant development.

The above posts are progressive and pensionable. The work is varied and interesting, and holds attractive prospects in an expanding field. 5-days' week. Canteen and Sports Club facilities.

Apply in writing, stating age, qualifications and salary expected, to:

Personnel Manager (L.G.2),
John Laing and Son Limited,
Building and Civil Engineering Contractors,
London N.W.7.

MISCELLANEOUS ADVERTISEMENTS.

(*Continued from page lxiv.*)

SITUATIONS VACANT. Draughtsmen—IMPERIAL SMELTING CORPORATION, LTD., Avonmouth, Bristol, requires experienced mechanical, electrical and structural/civil draughtsmen for design and detail work in connection with chemical and metallurgical plant and equipment. Salaries, working conditions and welfare facilities are good, and good prospects of promotion exist for young men holding or prepared to obtain H.N.C. or equivalent. Bus and train services to and from the works gates. Write to PERSONNEL MANAGER for application form, giving brief details of age, qualifications and experience, and quoting reference D/ECE.

SITUATION VACANT. Fully qualified and experienced contractor's engineer for head office required immediately. The post carries with it responsibility for correspondence with clients and also with the agents at various civil engineering sites, and the design of all falsework such as stagings, cofferdams, and plant layout. Apply in writing only, stating age, experience, and salary required, together with copies of any testimonials, to PETER LIND & CO., LTD., Romney House, Tufton Street, Westminster, S.W.1.

SITUATIONS VACANT. Reinforced concrete designers and detailers required. Permanent position with good prospects. Pension scheme, five-days' week, and luncheon vouchers. Write or telephone for interview. E. J. COOK & CO. (ENGINEERS), LTD., 54 South Side Clapham Common, London, S.W.4. MACaulay 5522.

SITUATIONS VACANT. TAYLOR WOODROW CONSTRUCTION, LTD., require structural designers. First class men, with reinforced concrete experience of design and detailing, for Head Office. The right men will have interesting and progressive positions. Write giving full details, which will be treated confidentially, to M.D. ENGINEER, Ruislip Road, Southall, Middlesex.

SITUATION VACANT. Supervisor required to control supplies of reinforcement, bar bending and fixing, and to inspect site work. Design and site experience desirable. Apply in writing, giving full details of age, education, previous experience, and salary required, to E. J. COOK & CO. (ENGINEERS), LTD., 54 South Side Clapham Common, London, S.W.4.

SITUATIONS VACANT. Consulting structural engineers require assistants with at least two years' office experience in design and/or detailing steel and reinforced concrete frameworks and foundations, following graduateship and National Service. Salary £500–£800 per annum, according to age, experience and qualifications. Apply ANDREWS, KENT & STONE, 60–66 Wardour Street, London, W.1. Telephone: Gerrard 9341.

SITUATIONS VACANT. Design-detailers required in Westminster consulting engineers' office. Experience in reinforced concrete structures essential. Staff pension scheme, luncheon vouchers, alternate Saturdays. Salary according to experience and qualifications. Apply in writing, giving full details of age and experience, to J. D. & D. M. WATSON, 18 Queen Anne's Gate, Westminster, S.W.1.

SITUATION VACANT. Senior designer-draughtsman required for Liverpool office of old-established reinforced concrete engineers. Applicants must be familiar with design of reinforced concrete frames and all forms of reinforced concrete floor construction. The post is permanent, progressive, and pensionable, and a substantial salary is offered for an experienced man. Write fully, Box 4191, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Civil engineering department of THE COPPEE COMPANY (GREAT BRITAIN), LTD., 140 Piccadilly, London, W.1, requires following staff for interesting and varied colliery structures. Reinforced concrete and steelwork designers of ten years' experience. Reinforced concrete and steelwork detailers of three years' experience. Five-days' week. Pension scheme. Write giving age, experience, and salary required.

SITUATION VACANT. Design engineer with good general experience in the design and construction of civil engineering work, particularly in reinforced concrete, required for the drawing office of a large firm of civil engineering contractors in South Lancashire. Applications should indicate qualifications, experience, and salary required. Box 4192, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

(*Continued overleaf.*)

MISCELLANEOUS ADVERTISEMENTS.

(*Continued from page lxv.*)

SITUATION VACANT. Civil engineer required to run small prestressed concrete factory in the Midlands. Design experience essential. House available if required. Box 4193, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Consulting civil engineer in Manchester requires experienced reinforced concrete and/or structural steelwork designers. Five-days' week. Salary according to qualifications and experience. Applications, stating age, qualifications and experience, to Bertram Done, 55 Cross Street, Manchester 2.

SITUATIONS VACANT. The British Reinforced Concrete Engineering Co., Ltd., have vacancies for reinforced concrete designers and detailers, with some experience, in their Stafford, London, Liverpool, Bristol, Glasgow, Newcastle-upon-Tyne and Leeds Offices. Staff pension scheme, and five-days' week. Apply in writing to Chief Engineer, Stafford.

SITUATION VACANT. Large company specialising in production of precast concrete products at works throughout the country require the services of an assistant general manager. Applicants must have good knowledge of the precast concrete industry from the works, sales and administrative sides. Successful applicant, if satisfactory, would have opportunity of becoming General Manager in a few years. Apply, stating age (only applicants between 30 and 42 will be considered), experience, salary required, etc., to Box No. 4194, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Draughtsman required by manufacturers of precast concrete units. Experience in taking details off architects' drawings essential. Box 4195, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Works foreman required by civil engineering firm for their precast concrete works. Box 4196, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete engineers require designers, detailers, and draughtsmen at their Keynsham (Bristol) office. Vacancies offer opportunity to work on a variety of structures, and salaries will be dependent on age, experience, etc. Previous similar experience an advantage but consideration will be given to other suitable applicants. Box 4198, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

CENTRAL ELECTRICITY AUTHORITY
SENIOR CIVIL ENGINEER
CHIEF ENGINEER'S DEPARTMENT, HEADQUARTERS

Applications are invited for the appointment of a SENIOR CIVIL ENGINEER in the Chief Engineer's Department at Headquarters in London. The salary for the appointment, which is superannuable, will be within the range £2,400–£2,900 per annum. Candidates should be corporate members of the Institution of Civil Engineers and have wide experience in the design and construction of large civil engineering works, preferably associated with thermal generating stations and hydro-electric projects. Duties will include the critical examination of civil engineering problems involved in the construction of new and extension of existing generating stations. Applications, stating age, qualifications, experience, present position, and salary, to be forwarded to D. Moffat, Director of Establishments, Winsley Street, London, W.1, to be received not later than 29th October, 1955. Quote AE/61c.

SITUATION VACANT. Site agent (civil engineer) required for large pile foundation work and silo construction in Turkey. Three-years' contract, starting January 1956. Good salary for engineer with the right experience and background. Write, giving full particulars, to Christiani & Nielsen, Ltd., Romney House, Tufton Street, London, S.W.1.

SITUATIONS VACANT. Quantity surveyors required immediately in Westminster office for preparation of estimates, interim and final valuations of reinforced concrete work in London and suburbs. Permanent positions with prospects offered to men of proven ability. Superannuation scheme available. Alternate Saturdays. Write, stating experience, age, and salary required. All replies strictly confidential. Box 4200, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer-detailer required by consulting engineers in Westminster area. Salary from £700 to £800 according to experience. Box 4199, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

LONDON COUNTY COUNCIL
ARCHITECT'S DEPARTMENT

Vacancies for Engineering Assistants (up to £783) and Engineer Grade III (up to £945) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from Architect (AR/EK/SE/3), The County Hall, S.E.1. (1278.)

SITUATIONS VACANT. The following are required immediately for new offices near Oxford Circus, and for work in a rapidly-expanding organisation.

1. Civil engineering draughtsmen.
2. Reinforced concrete: Designers and detailers.
3. Structural steelwork: Designers and detailers.
4. Drainage engineers and draughtsmen.
5. Tracers with at least two years' drawing-office experience. Salary £400–£450 per annum.
6. Men with an excellent knowledge of building construction capable of taking-off materials' lists for ordering purposes.

High salary and good working conditions are offered. Pension scheme in operation. Five-days' week. Holidays honoured this year. Apply in writing to THE CHIEF DESIGNER, BRIAN COLQUHOUN & PARTNERS, 18 Upper Grosvenor Street, London, W.1.

JOHN LIVERSEDGE & ASSOCIATES

Consulting Structural Engineers, invite immediate applications for the following additional drawing-office staff.

(*a*) Designer-detailers (3), minimum 3 years' experience, for reinforced concrete work of varied types. Structural steelwork experience an advantage;

(*b*) Detailer-draughtsmen (6), with experience in reinforced concrete detailing, preferably H.N.C. standard;

(*c*) Junior draughtsmen and juniors for training (6).

Modern office conditions, 5-days' week, good pay according to ability, with opportunity for advancement.

Applications to 42 Portland Place, London, W.1.

SITUATIONS VACANT. Reinforced concrete or steelwork draughtsmen and designers, age 21 to 35, wanted in medium size consulting engineers' office, Westminster, where specialisation is avoided and opportunity exists to learn all aspects of civil and structural engineering. Five-days' week. Box 4201, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. OVE ARUP & PARTNERS require structural designers and detailers in London. If you are interested in gaining experience by working on a variety of schemes of structural significance, apply to No. 8 Fitzroy Street, London, W.1. Telephone: Langham 7781.

SITUATIONS VACANT. Civil engineers required by large expanding company with overseas associates. Applicants must be qualified concrete specialists capable of controlling laboratory and field work with experience and full understanding of modern concrete practice and placing technique. Applicants are required for both London and provincial centres. Reply initially in confidence, stating age, qualifications, experience, and salary required, to READY MIXED CONCRETE LIMITED, Readymix House, 19 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Two structural engineers required for expanding consulting engineers' office. Minimum two years reinforced concrete. Structural steelwork an advantage. Opportunity for varied and interesting work. Good salary and prospects for right men. H. SMULLEN, 9 Mansfield Street, London, W.1. LANgham 9253. Write or telephone for interview.

SITUATIONS VACANT. Civil and structural engineering assistants and detailers experienced in reinforced concrete and/or structural steelwork required. Knowledge of design will be an advantage but not essential, depending on positions. The work is varied and offers scope for initiative. Five-days' week, pension scheme. Good salaries will be offered to suitable applicants who should state experience and salary required to ENGINEERING DEPARTMENT, FARMER AND DARK, Romney House, Tufton Street, London, S.W.1.

SITUATION WANTED.

SITUATION WANTED. Civil and structural engineer in Glasgow area offers his part-time services for design and detail of reinforced and prestressed concrete, and in general civil engineering work. Box 4197, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

STAFFORDSHIRE COUNTY COUNCIL
EDUCATION COMMITTEE

APPLICATIONS are invited for STRUCTURAL DRAUGHTSMEN (Salary £560–£640 per annum) with at least two years' experience in reinforced concrete and structural steel; higher national standard preferred.

Form of Application from:—
The County Education Architect,
"Green Hall",
Lichfield Road,
STAFFORD,

to be returned not later than 10 days after the date of this advertisement.

T. H. EVANS,
Clerk of the County Council.

(RefA/Staff/201/KEF)

TRANSLATIONS REQUIRED.

Competent reinforced concrete engineer required to translate technical matter from the Russian language to English. Part-time work. Box 4202, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

WANTED.

WANTED. Copies of "CONCRETE AND CONSTRUCTIONAL ENGINEERING" for March 1939, December 1943, February and March 1944, May 1945, and April 1948. Box 4203, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

STRUCTURAL ENGINEER

Required for

DEVELOPMENT WORK & DESIGN IN PRESTRESSED CONCRETE CONSTRUCTION.

Salary

£800 to £1,000

depending on experience.
Apply giving details of qualifications and experience to

UDALLS PRESTRESSED CONCRETE LTD.
West Quay Road, SOUTHAMPTON.
Telephone: Southampton 26367.

FOR SALE.

FOR SALE. Steel plates and sections to size. Tubes, fittings, etc. E. STEPHENS & SON, LTD., Bath Street, London, E.C.1. Clerkenwell 1731.

FOR HIRE.

FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, 21 Hobart House, Grosvenor Place, London, S.W.1.

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25 Newton Place
Charing Cross, C.3
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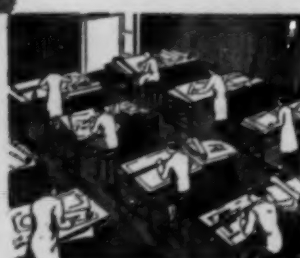

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